AMRL-TDR-63-35

408 980

THE RETENTION OF DISCRETE AND CONTINUOUS TASKS AS A FUNCTION OF INTERIM PRACTICE WITH MODIFIED TASK REQUIREMENTS

TECHNICAL DOCUMENTARY REPORT NO. AMRL-TDR-63-35

May 1963

Behavioral Sciences Laboratory
6570th Aerospace Medical Research Laboratories
Aerospace Medical Division
Air Force Systems Command
Wright-Patterson Air Force Base, Ohio

Contract Monitor: T. E. Cotterman
Project No. 1710, Task No. 171003

(Prepared under Contract No. AF 33(616)-7269 by
Donald R. Brown
George E. Briggs
James C. Naylor
Laboratory of Aviation Psychology, The Ohio State University,
Columbus, Ohio)

NOTICES

When US Government drawings, specifications, or other data are used for any purpose other than a definitely related government procurement operation, the government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise, as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

Qualified requesters may obtain copies from the Defense Documentation Center for Scientific and Technical Information (DDC), Arlington Hall Station, Arlington 12, Virginia. Orders will be expedited if placed through the librarian or other person designated to request documents from DDC (formerly ASTIA).

Do not return this copy. Retain or destroy.

Stock quantities available at Office of Technical Services, Department of Commerce $1.75.

Change of Address

Organizations receiving reports via the 6570th Aerospace Medical Research Laboratories automatic mailing lists should submit the addressograph plate stamp on the report envelope or refer to the code number when corresponding about change of address.

33-807, 700, 6-24-63

FOREWORD

This research was conducted in the Laboratory of Aviation Psychology at the Ohio State University as part of a program of research on "Techniques for Promoting the Long-Term Retention of Learned Skills," from May 1960 to August 1962. This study was conducted under Contract AF 33(616)-7269 between the Ohio State University Research Foundation and the Behavioral Sciences Laboratory, 6570th Aerospace Medical Research Laboratories, Aerospace Medical Division, in support of Project No. 1710, "Training, Personnel, and Psychological Stress Aspects of Bioastronautics," Task No. 171003, "Human Factors in the Design of Systems for Operator Training and Evaluation." The Principal Investigator was Dr. George E. Briggs. Dr. T. E. Cotterman, Operator Training Section, Training Research Branch, Behavioral Sciences Laboratory, served as contract monitor. Appreciation is expressed to Dr. Cotterman for his many positive contributions to the research planning and interpretation.

ABSTRACT

Laboratory research is reported on retention of continuous (tracking) and of discrete (procedural) tasks as a function of rehearsal conditions (simplified versus "operational" rehearsal tasks). All rehearsal conditions led to superior retention of the tracking task compared to a no-rehearsal condition, and certain of the procedural task scores indicated the same result. However, little evidence was found to indicate reliable differences among the several rehearsal conditions. It was concluded that sufficient original training will eliminate any potential differences among rehearsal conditions.

PUBLICATION REVIEW

This technical documentary report has been reviewed and is approved.

Walter F. Grether

WALTER F. GRETHER
Technical Director
Behavioral Sciences Laboratory

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

INTRODUCTION

The use of astronauts for vehicular control on space missions of several weeks duration raises the problem of possible loss of learned skills during the interval between the termination of premission training and that time in the mission when highly accurate vehicular control is required. Unless sufficient premission training is provided to avoid a loss of skill during the retention interval, some form of rehearsal should be provided in the space vehicle itself to enable the astronaut to practice any skills subject to forgetting. This raises two issues which are subject to laboratory research: how much original training is required to avoid, if possible, significant loss over a relatively long retention interval, and what should be the characteristics of such rehearsal tasks as may be required in the space vehicle? The present report is the second study, in a series of experiments on long-term retention, devoted to a specification of requirements for rehearsal tasks in a vehicular control system.

In the first study of rehearsal variables Naylor and Briggs (ref. 6) used a discrete procedural task patterned after the procedural panel which is used in the Project Mercury capsule to monitor and (if necessary) to provide manual control over discrete events in the orbit mission.* Naylor and Briggs found that rehearsal (which took place midway in a 25-day retention interval) on a task with modified temporal characteristics resulted in less retention of the original task requirements than that following rehearsal on a task with modified spatial characteristics. It was concluded that timing of responses was the more difficult task requirement and, therefore, temporal fidelity of rehearsal to operational tasks should be maintained.

These results are at variance with some earlier data by Bunch (refs. 1, 2) which suggested that activities performed during the retention interval tend to facilitate retention if the interval itself is of sufficient duration (120 days). Facilitation was found even when the interpolated activity possessed characteristics normally considered to be antagonistic, i.e., that would be expected to produce retroactive inhibition with retention intervals of short duration. Bunch used a finger maze, a task not too dissimilar to that employed by Naylor and Briggs in its basic demands on the subject, but of course the 25-day retention interval used by Naylor and Briggs was considerably shorter than that employed by Bunch, and he used a rehearsal maze in which both the temporal and the spatial patterns of required responses were different than those in the originally learned task. Thus, in the present study a longer retention interval was employed (37 days for all groups) and one group of subjects experienced a rehearsal task in which both the temporal and the spatial characteristics were modified compared to the originally learned procedural task.

The present study also included a three-dimensional tracking task over which the subject attempted to maintain continuous control while executing the procedural task responses. Reference again to the Mercury vehicle indicates that such a task

---

* While the Mercury system was not designed for missions of sufficient duration to raise a question of skill retention, that vehicle did provide the best reference tasks at the inception of this research program.

complex is more realistic than that used by Naylor and Briggs: operational aeronautical and aerospace vehicles require that the pilot or astronaut carry out continuous control and discrete procedural tasks simultaneously at certain phases of a mission, especially during landing or re-entry maneuvers.* The tracking task was patterned after the attitude control task present in the Mercury vehicle.

In summary, nine groups of subjects received eight daily sessions of training on what will be called the "operational" version of the tracking and procedural tasks followed by a retention interval of 37 days. Approximately midway in this interval, eight of the groups received four days of rehearsal either on the operational task or on a simplified version of that task; the ninth group received no rehearsal and serves, thereby, as a control group against which to compare the retention-test performance of the eight experimental groups. Four of these latter groups rehearsed on the operational tracking task, while the other four experienced a simplified version, and within each subset of four, there was one group for each of the four possible variations of the temporal and spatial characteristics of the procedural task (operational versus simplified).

No specific predictions were made concerning the relative retention levels of the nine groups, except for the expectation that all eight experimental groups would be superior to the control group at retention test. Instead, this was conceived to be an exploratory study to determine which of the previous results (Bunch versus Naylor and Briggs) more closely approximates retention performance on a more complex and realistic task. While there were few specific a priori hypotheses under test, there was a definite purpose to the study: to determine those aspects of an operational task complex which, for purposes of rehearsal, can be simplified (thus providing a savings in equipment space and weight) without significant loss in or interference with skill retention.

METHOD

Apparatus: The operational task on which subjects (Ss) were tested involved two independent components, each requiring qualitatively different responses. One task was procedural in nature, requiring discrete responses, while the second was a continuous, three-dimensional, compensatory tracking task. The experimental situation is shown schematically in figure 1.

The stimulus elements of the procedural task were provided by a panel of nine pairs of stimulus lights, each pair consisting of an amber light and a red light. The pairs of lights were arranged vertically on the panel with 1-inch separation between pairs. To the left of each light pair were three response buttons labeled "Emergency," "OK," and "Check." The occurrence of a particular light determined the appropriate response: S was to press only the OK button if an amber light occurred; however, he was instructed to press the emergency and

---

* Since re-entry maneuvers occur late in a mission, the possibility of forgetting those skills is greater than for skills to be executed closer in time to the termination of premission training; thus, it is felt that the present task complex provides a more useful basis upon which to generalize results than did the relatively simple task employed earlier by Naylor and Briggs.

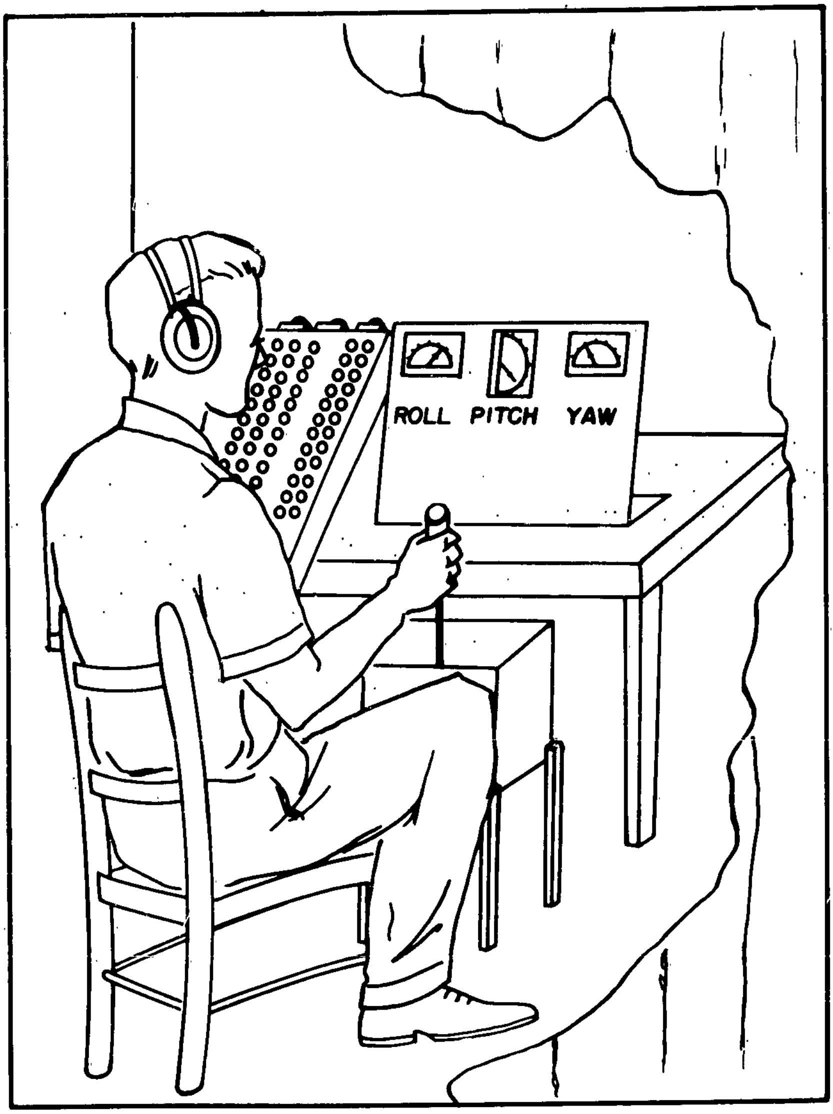

Figure 1. Line Drawing of the Experimental Booth.

OK buttons in sequence if a red light occurred, and if no light at all occurred at a specified time, S was to depress the check, emergency, and OK buttons in that order. The appropriate response or sequence of responses locked in the amber light, while a failure to produce the appropriate sequence resulted in the red light being locked in.

The procedural task panel, located approximately 24 inches from S's left shoulder and 30° to the left of center of his frontal vision, was rotated so that the plane area of the panel was maximal from S's regard. The apparatus included a 1-second stepping switch which allowed E to program (a) the spatial order of the nine stimulus events, (b) the duration of each stimulus event, (c) the time between the onsets of stimulus events, and (d) the preresponse condition (red, amber, or no light) for each stimulus event.

Two levels of procedural-task organization were used, where organization was defined in terms of the informational metric $\hat{H}$. Organization was determined in terms of the spatial contingencies of stimulus-event pairs, and since the sequence of positions involved sampling light positions without replacement, $\hat{H}$ could be calculated on the basis of the relationship between changes in light positions rather than on the basis of light positions themselves. The low-organization sequence was 1, 5, 2, 9, 8, 3, 6, 7, 3, where 1 refers to the top pair of lights, 2 to the next pair, etc. The value of $\hat{H}$ for this sequence was 2.808 bits. For a second sequence with higher organization (1, 2, 3, 4, 5, 6, 7, 8, 9) $\hat{H}$ was 0.000 bits. Both spatial sequences had been used in a prior retention study with this apparatus (ref. 8). Two temporal-interval sequences for stimulus events were also used. In the first, the temporal intervals between the onsets of successive lights were 4, 8, 10, 4, 10, 6, 6, and 8 seconds, while in the second condition there was a constant interval of 7 seconds between stimulus-event onsets (3 seconds for a stimulus event plus 4 seconds delay before the next stimulus event). The Ss were informed that the duration for each stimulus event was 3 seconds and that it was necessary to activate the appropriate response button or sequence of buttons within this time or the red light would become locked in.

The tracking task was a three-dimensional control device simulating the three attitude control dimensions (roll, pitch, and yaw) of a vehicle in free flight. Rate control dynamics were present in all three dimensions. The 19× 10.5-inch display panel was situated to the right of the procedural task display directly in front of S. The display consisted of three center-null-position meters, one each for roll, pitch, and yaw attitude error. The input signal was a simple sine wave generated by a Hewlett-Packard Model 202-A signal generator. Two input rates, 0.025 cps and 0.050 cps, were used under different experimental conditions (see table 1). The Ss tracked the signal in all three dimensions simultaneously using a three-dimensional control stick for his tracking responses. All control movement directions were compatible with the displays: (a) left-right (roll), (b) front-back (pitch), and (c) rotational (yaw).

Experimental Design: Experimental conditions during rehearsal were the critical experimental distinctions between groups of Ss. All groups were given original training on and were tested subsequently for retention with the same simulated operational task. The operational conditions were defined for the tracking task by an input of 0.05 cps and for the procedural task, the operational conditions were defined by the 1, 5, 2, 9, 8, 3, 6, 7, 4 spatial-order sequence ($\hat{H}$ = 2.808) and the 4, 8, 10, 4, 10, 6, 6, 8 second temporal-order sequence for stimulus events. Simplified conditions were used during rehearsal for certain of the groups and both the tracking task and the spatial and temporal characteristics of the procedural task were subjected to simplification. Simplified tracking was defined by an input signal of 0.025 cps and the simplified-spatial procedural task occurred in the 1, 2, 3, 4, 5, 6, 7, 8, 9 ($\hat{H}$ = 0.000) spatial sequence with a constant temporal interval of 7 seconds between stimulus-event onsets. The nine experimental conditions are summarized in table 1. An independent group of 14 Ss was assigned to each experimental condition.

TABLE 1

CONDITIONS DURING REHEARSAL DEFINING EIGHT EXPERIMENTAL CONDITIONS AND THE CONTROL CONDITION

Group	Tracking Task	Procedural Task	
		Temporal Sequence	Spatial Sequence
1	Simplified	Operational	Operational
2	Simplified	Operational	Simplified
3	Simplified	Simplified	Operational
4	Simplified	Simplified	Simplified
5	Operational	Operational	Operational
6	Operational	Operational	Simplified
7	Operational	Simplified	Operational
8	Operational	Simplified	Simplified
9	No Rehearsal	No Rehearsal	No Rehearsal

Note:—Operational Tracking Input: 0.050 cps
Simplified Tracking Input: 0.025 cps
Operational Temporal Sequence: 4, 8, 10, 4, 10, 6, 6, 8 sec.
Simplified Temporal Sequence: 7, 7, 7, 7, 7, 7, 7, 7 sec.
Operational Spatial Sequence: 1, 5, 2, 9, 8, 3, 6, 7, 4
Simplified Spatial Sequence: 1, 2, 3, 4, 5, 6, 7, 8, 9

Subjects and Procedure: A total of 126 male undergraduates served as Ss. All were volunteers who received $1.00 per experimental session. None had had previous experience with a laboratory tracking or procedural task.

The Ss were carefully instructed in the operation of both tasks during the first session. A part-task training procedure was followed during the first three daily sessions: during each session half the Ss received five 70-second trials on the procedural task followed by five 70-second trials on the tracking task; for the other Ss this order of part practice was reversed. Whole training, 10 trials on both tasks combined, was used for training during sessions 4 through 8. On each trial, S tracked for 70 seconds, but tracking performance was scored only during the last 60 seconds of each trial during which the procedural task also was operational. Four daily sessions of rehearsal were initiated 18 days following the last training session for all S in groups 1-8, and as in training, there were 10 70-second trials per rehearsal session. One retention test session was completed 15 days after the last rehearsal session, and the 10 trials were of the same duration as in the original training and rehearsal sessions.

Tracking performance was evaluated on the basis of integrated absolute error. Absolute error scores in voltage units were available for roll, pitch, and yaw separately and these were summed for purposes of later analysis. The separate scores were read to Ss at the end of each trial. Since the reader probably would have no direct appreciation for the data as expressed on a voltage scale, all tracking scores were subjected to a linear transformation to provide a scale of linear extent (inches) as determined by the relationship between a unit of voltage and the amount of deflection of a cursor on any one of the visual displays. On this more familiar scale, then, average error indicates the average (per S per dimension) intratrial variability of tracking error around zero error.

Procedural-task performance was scored in terms of (a) commissive errors (total button presses in excess of the required number and/or presses which were incorrect for the stimulus condition), (b) omissive errors (failures to respond correctly at the appropriate time), and (c) total response time for the nine stimulus events.

Each group of Ss practiced a constant spatial and temporal sequence during a particular experimental phase (training, rehearsal, and retention test) and for any given trial there were always four red lights and five amber lights. However, the actual stimulus event (red, amber, or no light) which occurred at a particular time and in a particular position changed for each S from trial to trial and from day to day. The schedule for stimulus events was as follows:

1. Session 1: No off-light conditions were used. There were four red lights and five amber lights on each trial.

2. Session 2: No off-light conditions on trials 1 and 3; one off-light on trials 2 (position 5), 4 (position 1), and 5 (position 9).

3. Session 3: No off-lights on trials 1 and 3; two off lights for trials 2 (positions 3 and 5), 4 (positions 1 and 9), and 5 (positions 1 and 6).

4. Sessions 4-8: Two off-lights on every trial with the particular lights varied from trial to trial.

The Ss were matched for assignment to the experimental (rehearsal) conditions on the basis of their tracking scores during training sessions 4 through 8.

RESULTS

Analysis of variance procedures were used to evaluate performance on both tasks. Separate analyses were performed on all metrics for the training data, for the retention test data, and for difference scores between training and retention-test performance levels.

Tracking Task: Tracking performance level during the three phases of the experiment are shown in figures 2 and 3. Performance is given in terms of average tracking error in inches of displacement as explained above. Performance for the first three days of training is not shown (and was not included in subsequent analyses) since a part-training schedule was used until the fourth day (see above) and thus the scores were not comparable to those for the rest of the experiment.

From these two figures, it appears that tracking performance was comparable for the nine groups during training, but apparent differences occurred during the rehearsal and retention test sessions. To determine whether the observed differences are reliable, analyses of variance were computed on tracking

TABLE 2

SUMMARY OF ANALYSES OF VARIANCE OF TRAINING DATA

Source	df	Tracking		Commissive Errors		Omissive Errors		Response Time	
		MS	F	MS	F	MS	F	MS	F
Tracking (T)	1	0.33	1.22	53.70	1.12	0.58	—	4.27	—
Procedural (P)	3	0.04	—	45.61	—	2.58	—	93.33	—
T × P	3	0.03	—	15.43	—	12.56	2.13	76.17	—
Ss/Groups	104	0.27		48.11		5.91		93.81	
Trials (Tr)	4	6.86	343.00**	42.27	11.84**	88.64	155.51**	1330.48	165.27**
Tr × T	4	0.01	—	7.18	2.01	0.17	—	4.89	—
Tr × P	12	0.03	1.50	2.40	—	0.46	—	6.31	—
Tr × T × P	12	0.01	—	2.91	—	0.40	—	3.96	—
Tr × Ss/G	416	0.02		3.57		0.57		8.05	

** $p < .01$

TABLE 3

SUMMARY OF ANALYSES OF VARIANCE OF DIFFERENCE SCORES

Source	df	Tracking		Commissive Errors		Omissive Errors		Response Time	
		MS	F	MS	F	MS	F	MS	F
Tracking (T)	1	0.029	2.63	13.64	2.73	0.136	—	2.20	—
Procedural (P)	3	0.017	1.55	4.21	—	1.135	1.33	23.75	1.86
T × P	3	0.005	—	6.02	1.20	2.474	2.90*	14.28	1.12
Ss/Cell	104	0.011		5.00		0.852		12.73	

* $p < .05$

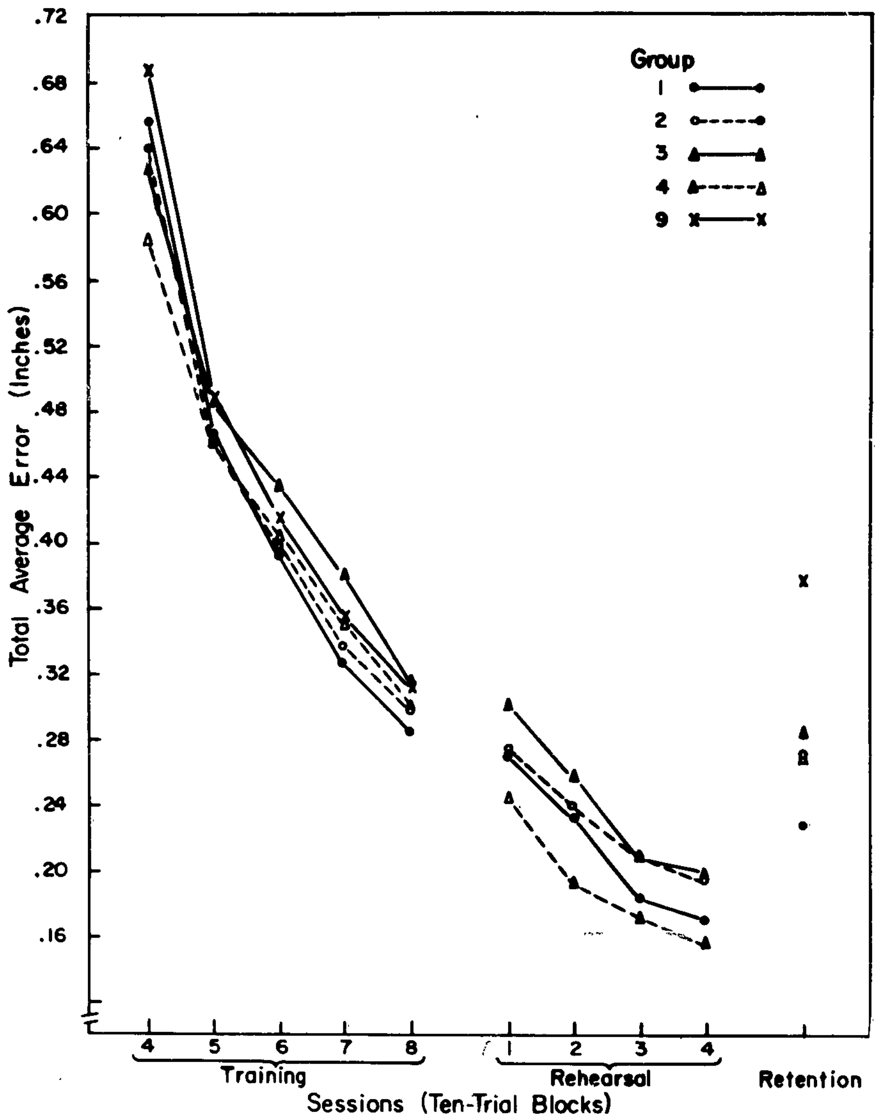

Figure 2. Tracking Performance during Training, Rehearsal, and Retention Test for Groups 1-4 and Control (Group 9).

performance during training (table 2), retention test* (table 4), and for difference scores between the last day of training and retention-test session (table 3). The results of the analysis of the training data are consistent with figures 2 and 3 and indicate that S matching procedures were adequate: the only reliable

---

* Performance for each S over the entire retention-test session (10 trials) served as the unit of analysis. Separate analyses were performed on the first retention-test trial; these results were the same as those from the entire session.

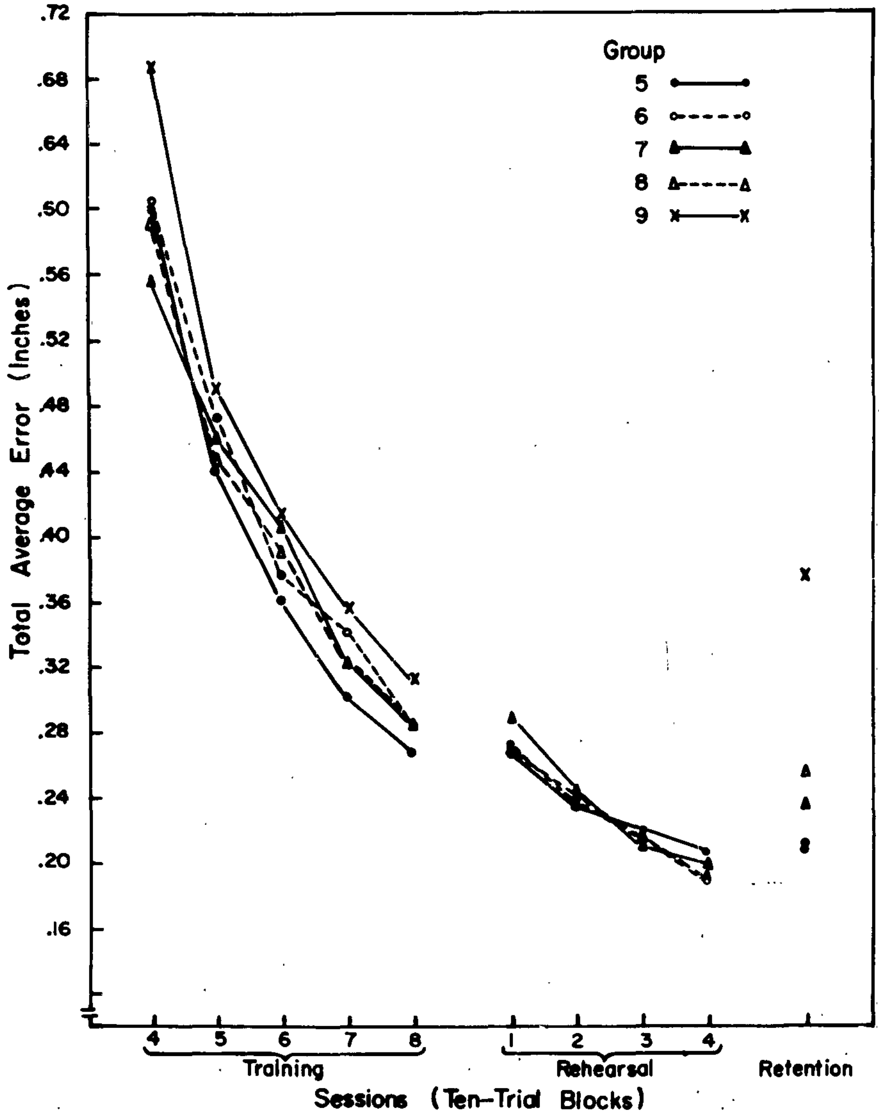

Figure 3. Tracking Performance during Training, Rehearsal, and Retention Test for Groups 5-8 and Control (Group 9).

difference ($p < .01$) was the trials effect (table 2). The analysis of tracking performance during retention test (table 4) and for the difference scores (table 3) both failed to demonstrate significant differences due to rehearsal conditions (tracking and procedural effects).

It follows from the latter that any of the versions of the rehearsal task (see groups 1-4 and 6-8 of table 1) was as effective as rehearsal on the operational task itself (group 5). This result is encouraging in that it suggests the use of simple rehearsal equipment which presumably would require less space and be of lesser weight than more elaborate equipment required to provide a higher level of

TABLE 4

SUMMARY OF ANALYSES OF VARIANCE OF RETENTION-TEST SCORES

Source	df	Tracking		Commissive Errors		Omissive Errors		Response Time	
		MS	F	MS	F	MS	F	MS	F
Tracking (T)	1	0.126	3.50	11.03	1.80	1.26	—	18.03	—
Procedural (P)	3	0.052	1.44	26.57	4.34**	2.38	1.71	58.53	2.78*
T × P	3	0.005	—	11.18	1.83	0.64	—	1.72	—
Ss/Cell	104	0.036		6.13		1.39		21.01	

* $p < .05$

** $p < .01$

fidelity of rehearsal to operational tasks. In other words, the designer of rehearsal equipment for space vehicles apparently has some latitude in his choice of the fidelity level for the same (or at least for statistically similar) rehearsal effectiveness. Probably, this is the most important conclusion from these data.

Whenever one finds no significant differences, a question of sensitivity or power is raised: what differences would have to exist among groups during retention test in order for the significance test to detect the difference at $p < .05$? With the error variance encountered in the retention data, a difference of 0.05 inch would be detected at $p < .05$ using the Duncan tables (ref. 3) for differences between two means. The authors conclude that this was a fairly sensitive experiment since it would be a most delicate vehicle control task for which an average error of 0.05 inch would make the difference between success and failure.

Since the control group (no rehearsal) was not, strictly speaking, part of the factorial design, the data for this group were not included in any of the above analyses of variance. To determine whether or not any of the eight experimental groups differed from the control group during the retention-test session, and on the basis of transfer from training to retention test (difference scores), Dunnett's test (ref. 4) was used to compare all treatment means with the control group mean. The results of these tests showed that all experimental groups were superior to the control group ($p < .05$) in tracking performance on the basis of both the retention test and the difference scores. The means upon which these analyses are based are shown in table 5. In this table, positive difference scores reflect improved performance across rehearsal while a negative difference demonstrates loss of proficiency between training and retention test. It is obvious that only the control group showed a loss in tracking skill between the end of training and the retention-test session.

In summary, the data from tracking accuracy indicate that a rehearsal task is desirable to avoid skill loss as evidenced by group 9; however, there appears

TABLE 5

MEAN TRACKING ACCURACY ON THE LAST TRAINING SESSION AND ON THE RETENTION-TEST SESSION

Rehearsal Group	Session 8	Retention Test	Difference
1	0.284	0.228	0.056
2	0.296	0.273	0.023
3	0.315	0.285	0.030
4	0.301	0.281	0.020
5	0.266	0.211	0.055
6	0.285	0.229	0.056
7	0.287	0.238	0.049
8	0.288	0.256	0.032
9	0.312	0.376	-0.065

to be some latitude in the fidelity of the rehearsal to the operational task as all versions employed here were statistically equivalent in their effects on retention.

Procedural Task: Procedural-task performance was evaluated on the basis of three measures: commissive errors, omissive errors, and response time. Analyses of variance on these measures are shown for training sessions in table 2 and for retention test in table 4. The analysis for difference scores is shown in table 3.

During training, the only significant differences which occurred were differences due to trials. All three metrics showed the expected practice effects ($p < .01$). These nonsignificant results are to be expected if subject-matching procedures were adequate.

The analysis of variance of retention-test scores (table 4) showed that both commissive errors ($p < .01$) and response time ($p < .05$) were sensitive to procedural task manipulation, while none of the procedural-task measures reflected reliable differences due to simplification of the tracking task (operational versus simplified) during rehearsal. To determine which of the four procedural-task conditions differed significantly during retention test, Duncan's test for differences between all possible pairs of means was used (ref. 3). These tests, summarized in table 6, showed significantly fewer commissive errors ($p < .05$) for those groups who received the operational procedural task during rehearsal when compared to all simplified-rehearsal conditions; and the number of commissive errors did not differ for comparisons among simplified

TABLE 6

SUMMARY OF DUNCAN TEST FOR COMMISSIVE ERRORS AND FOR RESPONSE TIMES AT RETENTION TEST

Procedural Task Conditions	Commissive Errors Groups				Response Time Groups			
	1 & 5	3 & 7	4 & 8	2 & 6	1 & 5	2 & 6	4 & 8	3 & 7
Temporal	O	S	S	O	O	O	S	S
Spatial	O	O	S	S	O	S	S	O
Average	1.41	2.26	2.30	2.51	9.11	9.40	10.04	10.92

Note: S = simplified, O = operational; means in brackets do not differ at $p < .05$.

rehearsal conditions themselves. The Duncan analysis on response time, also summarized in table 6, showed significantly longer response time when the groups who received simplified temporal rehearsal (groups 3 and 7) were compared to the operational-task rehearsal groups (groups 1 and 5).

The analysis of variance of procedural metrics based on difference scores (table 3) showed only one significant source of variance: a reliable ($p < .01$) tracking × procedural interaction for omissive errors indicates that the difference in number of omissive errors was jointly determined by manipulation of both tasks during rehearsal. The Duncan analysis (table 7), comparing all combinations

TABLE 7

SUMMARY OF DUNCAN TEST FOR OMISSIVE ERROR DIFFERENCES BETWEEN TRAINING AND RETENTION TEST

Task Conditions	Groups							
	6	4	7	3	1	2	8	5
Tracking	O	S	O	S	S	S	O	O
Temporal Procedural	O	S	S	S	O	O	S	O
Spatial Procedural	S	S	O	O	O	S	S	O
Average	-0.14	-0.12	-0.07	0.08	0.08	0.14	0.21	0.34

Note: S = simplified, O = operational; mean differences within brackets do not differ at $p < .05$.

of the eight experimental groups, showed significant differences between group 5 which rehearsed under all operational conditions and groups 4 (simplified tracking, simplified spatial, and simplified temporal), 6 (operational tracking, simplified spatial, and operational temporal), and 7 (operational tracking, operational spatial, simplified temporal).

Finally, Dunnett's procedure was used to compare control group means with all experimental group means for the three procedural task metrics during retention and on the basis of difference scores. The means upon which these tests were based and the results of the tests are shown in tables 8, 9, and 10.

From table 8 it may be seen that the number of commissive errors made during retention test by groups 1 (simplified tracking, operational procedural task) and 5 (operational tracking, operational procedural) was significantly smaller ($p < .05$) than that of the control group mean difference score.

Both retention-test scores and difference scores for omissive errors differentiated some experimental groups from the control group (table 9). In fact, of the 16 comparisons made with control group performance, only two experimental groups failed to make fewer omissive errors at retention test or to show significant change in performance from training to retention test: group 4, which rehearsed under all simplified conditions, and group 7, which had a simplified temporal sequence, did not differ from the control group.

Mean response time is shown in table 10 for all groups. Dunnett comparisons failed to show differences between any experimental groups and the control group.

TABLE 8

MEAN NUMBER OF COMMISSIVE ERRORS FOR TRAINING, RETENTION TEST, AND DIFFERENCE SCORES FOR ALL GROUPS

Group	Group Mean		Difference
	Session 8	Retention	
1	1.62	1.14*	0.48
2	2.29	2.77	-0.48
3	1.84	1.74	0.10
4	2.30	2.20	0.10
5	2.16	1.68*	0.48
6	2.79	2.26	0.53
7	2.92	2.78	0.14
8	2.86	2.40	0.46
9	2.35	2.62	-0.27

* Indicates group mean or difference differed significantly from the control group at $p < .05$.

TABLE 9

MEAN NUMBER OF OMISSIVE ERRORS FOR TRAINING, RETENTION TEST, AND DIFFERENCE SCORES FOR ALL GROUPS

Group	Group Mean		Difference
	Session 8	Retention	
1	0.84	0.76*	0.08*
2	1.23	1.09	0.14*
3	1.22	1.14	0.08*
4	1.02	1.14	-0.12
5	1.14	0.80*	0.34*
6	0.80	0.94*	-0.14
7	1.05	1.12	-0.07
8	1.06	0.85*	0.21*
9	1.14	1.30	-0.16

* Indicates group mean or difference differed significantly from the control group at $p < .05$.

TABLE 10

MEAN RESPONSE TIME FOR TRAINING, RETENTION TEST, AND DIFFERENCE SCORES FOR ALL GROUPS

Group	Group Mean		Difference
	Session 8	Retention	
1	9.92	9.44	0.48
2	10.36	10.00	0.36
3	11.24	10.97	0.27
4	9.81	10.26	-0.45
5	10.26	8.78	1.48
6	9.53	8.81	0.72
7	10.38	10.88	-0.50
8	10.06	9.83	0.23
9	10.34	10.92	-0.58

The major findings from the procedural-task metrics appear to be that retention was largely unaffected by manipulating tracking task parameters. Most of the significance obtained by comparisons among experimental groups can be accounted for in terms of procedural task parameters during rehearsal. In particular, better performance was associated with continued practice on the operational task during rehearsal. Comparisons with control group performance support the same conclusion.

DISCUSSION

The data are consistent with the results obtained by Bunch (refs. 1, 2) but not entirely with those reported by Naylor and Briggs (ref. 6). Bunch's work indicated that when retention intervals are long, various interpolated activities lead to increased retention of the original skill. The tracking results of this study strongly support this same conclusion. All groups, including those which practiced with simplified tracking and procedural task conditions during rehearsal, were superior to the control group in tracking skill after a retention interval of 2 weeks, and no reliable differences were found among the groups which experienced different rehearsal conditions. The procedural task metrics were not all sensitive to these effects. Response time completely failed to show differences between experimental groups and the no-rehearsal (control) conditions, and the number of commissive errors showed superiority over the control group only for the group which rehearsed on the original training task. In contrast, the number of omissive errors differentiated most experimental groups from the control condition.

Naylor and Briggs (ref. 6) found that changing the spatial characteristics of the procedural task during rehearsal had little effect upon the later retention of the original task. In contrast, changing the temporal characteristics of the task led to degradation of retention similar to that manifested by Ss who received no interim practice at all. The present data do not support this findings. Commissive errors, for instance, showed that only the group which rehearsed the original training task was superior during retention test to the no-rehearsal control group. No differences were observed among groups who rehearsed with modified procedural-task characteristics and none of these groups differed from the control condition. The only differences which support the conclusion that practice with modified temporal conditions degrades retention more than does interim practice with modified spatial characteristics were those involving response-time scores. During retention test, response time for the modified temporal group was significantly greater than that for the operational rehearsal group. Modifying only the spatial, or both the spatial and temporal aspects of the task, did not alter retention-test performance.

While these procedural task results appear to be contradictory to the previously reported findings with the same task, the contradiction is more apparent than real. If rehearsal with modified temporal characteristics leads to decreased retention of the original task skill because of the effects of retroactive inhibition, it simply may be that the inhibitory effects are of short duration and do not manifest themselves with intervals of the duration used herein. Previous research indicated that such effects are of relatively limited duration (ref. 5). However, the explanation advanced by Naylor and Briggs (ref. 6) for their data was that the differential effects of spatial and temporal rehearsal conditions were due to differential difficulty of the two aspects of the task, i.e., temporal task characteristics were more demanding. Modification during rehearsal led to less practice on this task aspect and, therefore, led to greater loss of original skill at retention test. This explanation appears most plausible as a basis for rationalizing the difference between their results and those of the present study. Other research (ref. 8) has shown that retention performance differences between rehearsal conditions for groups which received one week of original training no longer manifest themselves with groups which had two weeks of initial training. Since Naylor and Briggs used one week of training, and since two weeks of training were used in the present study, it seems reasonable to assume that the amount of original training used here led to skill levels which washed out the previously observed effects of rehearsal conditions. The additional practice, needed to maintain skill on the more difficult temporal demands of the procedural task, previously afforded during rehearsal for some groups, was provided in the present study during original training. Consequently, differences between rehearsal conditions no longer manifested themselves.

These results indicate that any task should be dimensionalized in terms of separate task components of subtasks as well as in terms of the subtasks of the more global task. Where training time is available, sufficient training on the whole task can be expected to negate the benefit derived from differential rehearsal on separate task components. When training time is limited, however, or when the retention interval is of such duration as to permit forgetting even though extended original training was provided, additional interim practice on the more difficult aspects of the subtasks would be expected to lead to superior retention of the original task skill.

The reader should note that the above conclusions are based on statistical analyses with an α level of 0.05. Had a less stringent level been adopted for Type I errors, it is apparent that certain of these conclusions would have been modified. For example, in table 4 the tracking mean square for the simplified versus operational tracking task comparison (T) just missed significance at $\underline{p} < .05$. Had the α level been set at 0.10, one could conclude that a reliable difference did exist between these rehearsal conditions. Thus, from column 3 of table 5 it would follow that retention performance was better when an operational tracking task was experienced during rehearsal than when S rehearsed on a simplified tracking task; the average performance of groups 5-8 was 0.234 compared to the average of groups 1-4 which was 0.267.

The reader is free, of course, to adopt any level for the Type I error he wishes. The authors do feel that an α level of 0.05 is appropriate and so we stand behind the conclusions reached in the body of this report.

SUMMARY

The purpose of this study was to examine the effects of various rehearsal techniques upon the retention of a continuous tracking task and discrete procedural task. Rehearsal conditions for the tracking task were either operational or simplified. The procedural task was dimensionalized on the basis of its spatial and temporal characteristics and groups rehearsed with all combinations of operational and simplified conditions for both dimensions.

Nine groups of 14 subjects each trained for 8 days on the whole task. Eighteen days following the last day of training, the experimental groups returned for 4 days of rehearsal. One retention test session was completed 15 days after rehearsal.

All rehearsal groups were superior in tracking skill to the no-rehearsal control group at retention test. No difference in tracking skill was observed among rehearsal conditions. The procedural task metrics were less sensitive in comparison with control group subjects, but commissive errors demonstrated the superiority of operational-task rehearsal to no rehearsal, and the number of omissive errors showed less loss of skill for most rehearsal conditions when compared to the control group. Differences in performance on the procedural task among rehearsal groups were largely attributable to differences between rehearsal on the operational task and rehearsal under the simplified task conditions. It was concluded that differences among rehearsal conditions are largely negated when original training is of sufficient duration.

REFERENCES

1. Bunch, M. E., "Transfer of Training in the Mastery of an Antagonistic Habit after Varying Intervals of Time," Journal of Comparative Psychology, Vol 28, pp 189-200, 1939.

2. Bunch, M. E., "Retroactive Inhibition or Facilitation from Interpolated Learning as a Function of Time," Journal of Comparative Psychology, Vol 39, pp 287-291, 1946.

3. Duncan, D. G., "Multiple Range and Multiple F Tests," Biometrics, Vol 11, pp 1-42, 1955.

4. Dunnett, C. W., "A Multiple Comparison Procedure for Comparing Several Treatments with a Control," Journal of the American Statistical Association, Vol 50, pp 1096-1121, 1955.

5. Lewis, D., "Latest News and Views Regarding Individual Susceptibility to Interference in the Performance of Perceptual Motor Tasks," presented at Midwestern Psychological Association, Chicago, Ill., 1959.

6. Naylor, J. C., and G. E. Briggs, "The Effect of Rehearsal of Temporal and Spatial Aspects on the Long-Term Retention of a Procedural Skill," Journal of Applied Psychology, 1963, in press.

7. Naylor, J. C., G. E. Briggs, D. R. Brown, and W. G. Reed, The Effect of Rehearsal on the Retention of a Time-Shared Task, AMRL Technical Documentary Report, 6570th Aerospace Medical Research Laboratories, Aerospace Medical Division, Wright-Patterson Air Force Base, Ohio, 1963.

8. Naylor, J. C., G. E. Briggs, and W. G. Reed, The Effects of Task Organization, Training Time, and Retention Interval on the Retention of Skill, AMRL-TDR-62-107, 6570th Aerospace Medical Research Laboratories, Aerospace Medical Division, Wright-Patterson Air Force Base, Ohio, September 1962.

Aerospace Medical Division,
6570th Aerospace Medical Research
Laboratories, Wright-Patterson AFB, Ohio
Rpt. No. AMRL-TDR-63-35.
THE RETENTION OF DISCRETE AND CONTINUOUS TASKS AS A FUNCTION OF INTERIM PRACTICE WITH MODIFIED TASK REQUIREMENTS. Final report, May 63, vi + 18 pp incl. illus., tables, 8 refs. Unclassified Report

Laboratory research is reported on retention of continuous (tracking) and of discrete (procedural) tasks as a function of rehearsal conditions (simplified versus "operational" rehearsal tasks). (over)

UNCLASSIFIED

1. Training and Training Aids
2. Retention (Skill)
3. Learning (Psychology)

I. AFSC Project 1710, Task 171002
II. Behavioral Sciences Laboratory
III. Contract AF 33 (616)-7269
IV. Laboratory of Aviation Psychology, Ohio State University, Columbus, O.

UNCLASSIFIED

All rehearsal conditions led to superior retention of the tracking task compared to a no-rehearsal condition, and certain of the procedural task scores indicated the same result. However, little evidence was found to indicate reliable differences among the several rehearsal conditions. It was concluded that sufficient original training will eliminate any potential differences among rehearsal conditions.

UNCLASSIFIED

V. Brown, D. R. Naylor, J. C. Briggs, G. E.
VI. In ASTIA Collection
VII. Aval Fr OTS: $1.75

UNCLASSIFIED

Aerospace Medical Division,
6570th Aerospace Medical Research
Laboratories, Wright-Patterson AFB, Ohio
Rpt. No. AMRL-TDR-63-35.
THE RETENTION OF DISCRETE AND CONTINUOUS TASKS AS A FUNCTION OF INTERIM PRACTICE WITH MODIFIED TASK REQUIREMENTS. Final report, May 63, vi + 18 pp incl. illus., tables, 8 refs. Unclassified Report

Laboratory research is reported on retention of continuous (tracking) and of discrete (procedural) tasks as a function of rehearsal conditions (simplified versus "operational" rehearsal tasks). (over)

UNCLASSIFIED

1. Training and Training Aids
2. Retention (Skill)
3. Learning (Psychology)

I. AFSC Project 1710, Task 171002
II. Behavioral Sciences Laboratory
III. Contract AF 33 (616)-7269
IV. Laboratory of Aviation Psychology, Ohio State University, Columbus, O.

UNCLASSIFIED

All rehearsal conditions led to superior retention of the tracking task compared to a no-rehearsal condition, and certain of the procedural task scores indicated the same result. However, little evidence was found to indicate reliable differences among the several rehearsal conditions. It was concluded that sufficient original training will eliminate any potential differences among rehearsal conditions.

UNCLASSIFIED

V. Brown, D. R. Naylor, J. C. Briggs, G. E.
VI. In ASTIA Collection
VII. Aval Fr OTS: $1.75

UNCLASSIFIED